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PATENT SPECIFICATION

DRAWINGS ATTACHED

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Inventors:—MICHAEL POUCHER and JAMES ALEXANDER PETRIE.

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Int. Cl.:—**F 01 d 5/14**.

COMPLETE SPECIFICATION

Method of making an aerofoil shaped blade for a fluid flow machine

We, ROLLS-ROYCE LIMITED, a British company of Nightingale Road, Derby, Derbyshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns a method of making an aerofoil-shaped blade for a fluid flow machine, such, for example, as a gas turbine engine, and also concerns a blade made by said method.

The term " blade " as used in this specification is intended to include both large fan blades, for which the present invention is particularly suitable, and also blade-like members such an inlet guide vanes, nozzle guide vanes, and aerofoil-shaped struts extending across the fluid duct of a gas turbine engine.

According to the present invention, there is provided a method of making an aerofoil-shaped blade for a fluid flow machine comprising forming the blade of two separate wall members which are bonded to each other and to an expanded multi-cellulor honeycomb structure disposed between the wall members.

The term " bonded " as used in this specification is intended to include both the use of a bonding agent and also welding.

The honeycomb structure and wall members may be made of the same or of a different metal or alloy. Alternatively, the honeycomb structure may be made of fibre-reinforced synthetic resin material.

The said wall members may be sheet metal members or may be forgings which have been hot pressed to give them the desired camber and stagger.

Each wall member may be welded or otherwise bonded to a part of a root portion of the blade, and the said parts of the said root portion may thereafter be bonded to each other.

The surface of the said root portion may be curved to follow the blade profile.

Prior to the parts of the said root being bonded to each other, the said parts and the wall members bonded thereto may be etched and electro-chemically machined at the surfaces which are to be bonded.

Different portions of the honeycomb structure may have different densities. The said portions of the honeycomb structure may be portions of a single integral structure and may have been stretched in a non-uniform manner.

Alternatively, the said portions of the honeycomb structure may be separate from each other and may, for example, be of different gauge material and/or different cell size.

Preferably the portion of the honeycomb structure adjacent the leading edge of the blade has a higher density than the portion adjacent the trailing edge of the blade.

The honeycomb structure may be bonded to one of the wall members and then machined, the other wall member then being bonded both to the honeycomb structure and to the said one wall member.

The leading edge of the blade may be coated with a coating of polyurethane to protect and reinforce the joint at the leading edge between the said wall members. The said coatings may have a wire gauze embedded therein.

The joint between the said wall members at the leading edge portion of the blade may be displaced from the leading edge proper.

The invention also comprises an aerofoil-shaped for a fluid flow machine, e.g. a compressor rotor blade of a gas turbine engine, when made by the method set forth above.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:

Figure 1 is a view, partly in section, of a gas turbine engine,

Figure 2 is a sectional plan view of one of the blades of said engine,

Figure 3 is a section taken on the line 3-3 of Figure 2, and

Figure 4 is a view similar to that of Figure 2 but illustrating a modification.

In Figure 1 there is shown a gas turbine engine 10 having an engine casing 11 within which there are mounted in flow series a compressor 12, combustion equipment 13, and a turbine 14.

The compressor 12 has rotor blades 15, each of which is formed by two wall members 16, 17 (Figures 2 and 3) with a honeycomb structure 18 disposed therebetween. The honeycomb structure 18 is an expanded multicellular structure i.e. one in which the space between the walls is large compared with the thickness of the walls.

The wall members 16, 17 are initially produced from titanium sheet or plate or from titanium alloy forgings which have been hot pressed to give them the desired camber and stagger.

The wall members 16, 17 are respectively electron beam welded to parts 20, 21 of a root portion 22 of the blade 15, after which these parts are inspected and dressed. The root portion 22 may either have a straight centre line, as shown, or one which is curved so that the surface of the root portion is carried to follow the blade profile. In the latter case, it is not necessary to provide transition pieces between the root portion and the blade proper, and the blade may be provided with a shroud portion formed separately therefrom

The root portions 20, 21 and the wall members 16, 17 which have been welded thereto are then etched and electrochemically machined at surfaces such as the surface 23 which are thereafter to be bonded to each other.

The honeycomb structure 18, which may be formed of aluminium or an aluminium alloy, is then bonded to one of the wall members e.g. to the wall member 17. The honeycomb srtucture 18 is then machined to a form such that the wall member 16 can be bonded both to the honeycomb structure 18 and to the blade wall member 17. Such bonding is then effected at the root portion 22, at the leading edge 24, and at the trailing edge 25.

The bonding agent which may be employed for all the said bonding steps may be a polyurethane resin or may be bonding agents marketed under the names "ECCOBOND 04", "HIDUX FILM ADHESIVE", "NML 35" or "BSL 308".

Alternatively, the honeycomb structure 18 could also be made of titanium or a titanium alloy, or could be made of glass or other fibre-reinforced synthetic resin material.

The leading edge 24 of each blade 15 is finally coated with a coating of a polyurethane resin (e.g. that sold under the Trade Mark "ADIPRENE"), in order to protect and reinforce the joint at the leading edge 24 between the wall members 16, 17. This coating (not shown) may moreover be reinforced by titanium wire gauze (not shown) being embedded therein. The said joint, moreover, may be somewhat displaced from the leading edge proper so as to be disposed on the convex side of the blade. This reduces the risk that a foreign body will strike the joint and force it open.

If desired, the wall members 16, 17 may alternatively be bonded together by radial strips of glass fibre.

As will be seen from Figure 2, the portions of the wall members 16, 17 adjacent the leading edge 24 are thicker than the main portions thereof so as to improve the resistance of the blades 15 to hard foreign objects and also to move the centre of gravity of the blades forwards of the mid-chord position.

The blades 15 described above are relatively simple to manufacture and have considerable stiffness while providing vibration damping.

As shown in Figure 4, the honeycomb structure may be in two portions 26, 27 which are respectively disposed adjacent the leading edge 24 and the trailing edge 26. The portions 26, 27 are spaced by an axial gap 28 which may, however, be omitted so that the portions 26, 27 contact but are separated from each other. The portion 26 is of relatively thick gauge material and/or has cells of relatively small size, while the portion 27 is of relatively thin gauge material and/or has cells of relatively large size. Thus the density of the portion 26 adjacent the leading edge 24 is higher than that of the portion 27 adjacent the trailing edge 25.

Alternatively, the honeycomb structure could be a single integral structure having portions of different densities, e.g. by being stretched in a non-uniform manner. Thus the density could vary progressively from the leading to the trailing edge of the blade.

The arrangement illustrated in Figure 4 enables the centre of gravity of the blade to be moved towards the mid-chord position and this in turn enables the wall members 16, 17 to be made symmetrical about the mean line. The blade may, moreover, thereby be made stronger when heavy ingestion loads are applied.

WHAT WE CLAIM IS:—

1. A method of making an aerofoil-shaped blade for a fluid flow machine comprising forming the blade of two separate wall members which are bonded to each other and to an expanded multi-cellular honeycomb structure disposed between the wall members.

2. A method as claimed in claim 1 in which the honeycomb structure and wall members are made of metal or alloy.

3. A method as claimed in claim 2 in which the honeycomb structure is made of a different metal or alloy from that of the wall members.

4. A method as claimed in claim 1 in which the honeycomb structure is made of fibre-reinforced synthetic resin material.

5. A method as claimed in any preceding claim in which the said wall members are sheet metal members or are forgings which have been hot pressed to give them the desired camber and stagger.

6. A method as claimed in any preceding claim in which each wall member is bonded to a part of a root portion of the blade, and the said parts of the root portion are thereafter bonded to each other.

7. A method as claimed in claim 6 in which the surface of the said root portion is curved to follow the blade profile.

8. A method as claimed in claim 6 or 7 in which, prior to the parts of the said root portion being bonded to each other, the said parts and the wall members bonded thereto are etched and electro-chemically machined at the surfaces which are to be bonded.

9. A method as claimed in any preceding claim in which different portions of the honeycomb structure have different densities.

10. A method as claimed in claim 9 in which the said portions of the honeycomb structure are portions of a single integral structure.

11. A method as claimed in claim 9 or 10 in which the portions of the honeycomb structure have been stretched in a non-uniform manner.

12. A method as claimed in claim 9 in which the said portions of the honeycomb structure are separate from each other.

13. A method as claimed in claim 12 in which the separate portions of the honeycomb structure are of different gauge material and/or of different cell size.

14. A method as claimed in any of claims 9 to 13 in which the portion of the honeycomb structure adjacent the leading edge of the blade has a higher density than the portion adjacent the trailing edge of the blade.

15. A method as claimed in any preceding claim in which the honeycomb srtucture is bonded to one of the wall members, and is then machined, the other wall member then being bonded both to the honeycomb structure and to the said one wall member.

16. A method as claimed in any preceding claim in which the portion of the blade adjacent the leading edge is coated with a coating of polyurethane to protect and reinforce the joint adjacent the leading edge between the said wall members.

17. A method as claimed in claim 16 in which the said coating has wire gauze embedded therein.

18. A method as claimed in any preceding claim in which the joint between the said wall members at the leading edge portion of the blade is displaced from the leading edge proper.

19. A method of making an aerofoil-shaped blade for a fluid flow machine substantially as hereinbefore described with reference to and as shown in Figures 2 to 4 of the accompanying drawings.

20. An aerofoil-shaped blade for a fluid flow machine when made by the method claimed in any preceding claim.

21. A compressor rotor blade of a gas turbine engine made by the method claimed in any of claims 1 to 16.

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1,130,285 COMPLETE SPECIFICATION

2 SHEETS

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SHEETS 1 & 2

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Fig.4

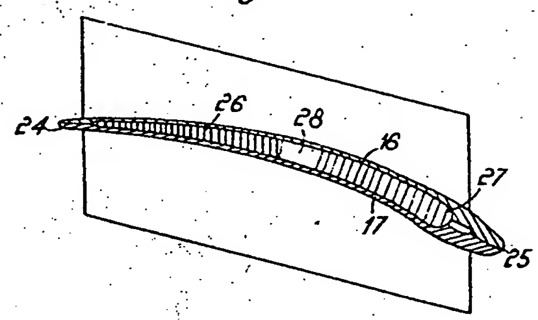

Fig.1.

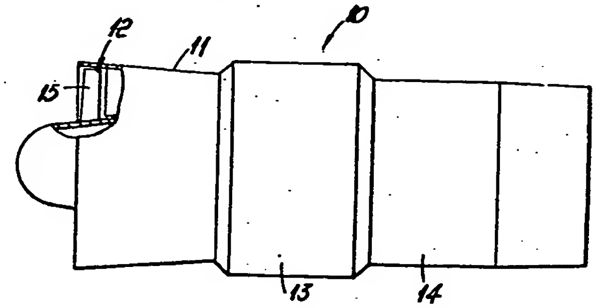

Fig.2.

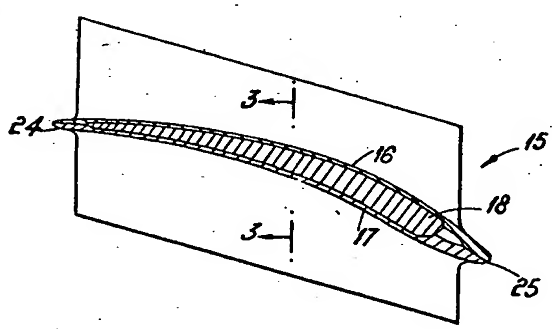

Fig.3.